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BALD EAGLE RESPONSE TO BOATING ACTIVITY IN NORTHCENTRAL FLORIDA

PETRA BOHALL WOOD
West Virginia Cooperative Fish and Wildlife Research Unit, Biological Resources Division, USGS and West Virginia University Division of Forestry, Morgantown, WV 26506-6125 U.S.A.

ABSTRACT.—I examined the effects of weekend and weekday boating activity on Bald Eagle (*Haliaeetus leucocephalus*) use of three lakes in northcentral Florida during 1988–89. On Lake Lochloosa, which had the highest number of boats of the three lakes, boating activity significantly reduced the numbers of all age classes of eagles using the lake ($P < 0.025$). Increased boating activity on Lake Wauberg was not related to use by eagles ($P = 0.06$) likely because boating activity was concentrated during midday while eagles typically foraged early and late in the day. On Newnan's Lake, the number of eagles observed also was not different between weekends and weekdays ($P = 0.20$). Weekend boating activity did not relate to perch use, habitat use, interactions or age distribution indicating no alteration of eagle behavior patterns. Flush distance did not vary between weekends and weekdays ($P = 0.96$), but did vary by month ($P = 0.0001$), with a greater flush distance during months with highest boating activity. Minimal flush distances ($\bar{x} = 53$m) and lack of measurable effects on behavior suggested that eagles in my study area were tolerant of boat disturbance.

KEY WORDS: *Bald Eagle*; Haliaeetus leucocephalus; *boat disturbance*; *Florida*; *human activity*.

Respuesta de *Haliaeetus leucocephalus* a actividades de canotaje en el centronorte de Florida

RESUMEN.—Examiné los efectos de canotaje durante los fines de semana y durante la semana en águilas calvas (*Haliaeetus leucocephalus)* en tres lagos del centronorte de Florida durante 1988–89. En el lago Lochloosa el cual tiene el mayor número de botes de los tres lagos, las actividades de canotaje redujeron significativamente los números de todas las clases de edad de las águilas que utilizaron el lago ($P < 0.025$). El incremento en el canotaje del lago Wauberg no fué relacionado con el uso por parte de las águilas ($P = 0.06$), debido a que las actividades de canotaje se concentraron durante el medio día, mientras que las águilas forrajeaban temprano en la mañana o tarde durante el día. En el lago Newnan, el número de águilas observadas no fué diferente entre los fines de semana y entre semana ($P = 0.20$). Las actividades de canotaje durante el fin de semana no estuvieron relacionadas con la utilización de perchas, uso de habitat, interacciones o distribución de edades lo que indicó que no hubo alteraciones en los patrones de comportamiento de las águilas. Las distancias a las cuales las águilas levantaban el vuelo no variaron entre fines de semana y entre semana ($P = 0.96$), pero sí entre meses ($P = 0.0001$), con una mayor distancia de levantamiento de vuelo durante los meses con mayor canotaje. La distancia de levantamiento de vuelo mínima ($\bar{x} = 53$ m) y la falta de efectos medibles en el comportamiento sugieren que las águilas en mi estudio son tolerantes a la perturbación de los botes.

[Traducción de César Márquez]

Boating activity can modify foraging patterns of Bald Eagles (*Haliaeetus leucocephalus*) by reducing or even precluding use of foraging areas (Steenhof 1976, Stalmaster and Newman 1978, Knight and Knight 1984, Chester et al. 1990, McGarigal et al. 1991, Brown and Stevens 1997). McGarigal et al. (1991) concluded that boating activities restrict use of certain foraging areas by breeding eagles and ultimately may affect productivity. Since Bald Eagles are easily disturbed when foraging (Grubb and King 1991) and adults are more sensitive to disturbance than younger eagles (Stalmaster and Newman 1978), increasing recreational use of lakes in Florida may pose problems for breeding eagles. In addition, the dense eagle population in Florida that exists in close proximity to high levels of human activity provided an opportunity to determine if eagles habituate to human activity.

I conducted a study to examine the effects of boating activity on the use of lake shorelines by Bald Eagles and addressed the following objectives: (1) to determine if the number of Bald Eagles ob-

Table 1. Mean number of Bald Eagles and boats on weekend (WE) and weekday (WD) counts on shoreline surveys of three lakes in northcentral Florida, 1988 and 1989.

			Number of Eagles						Number of Boats					
Lake	Year	N[a]	$\bar{x}$ WE	(Range)	$\bar{x}$ WD	(Range)	t	P	$\bar{x}$ WE	(Range)	$\bar{x}$ WD	(Range)	t	P
Lochloosa	1988	10	3.2	(0–10)	6.1	(1–10)	−3.36	0.005	28.7	(4–50)	5.8	(4–31)	4.06	0.005
	1989	10	6.9	(0–11)	10.6	(3–20)	−2.38	0.025	17.9	(12–24)	7.8	(3–16)	5.37	0.005
Newnans	1988	12	4.2	(1–11)	5.3	(1–9)	−0.95	0.20	18.5	(5–36)	11.5	(2–23)	5.02	0.005
	1989	12	8.2	(3–20)	8.3	(2–14)	−0.19	0.30	8.6	(2–16)	5.5	(0–13)	2.94	0.01
Wauberg	1988	10	2.5	(1–6)	4.2	(0–11)	−1.66	0.06	6.7	(1–19)	3.5	(0.10)	1.61	0.06
	1989	14	5,6	(1–11)	6.1	(1–11)	−0.43	0.25	12.8	(2–32)	4.7	(0–8)	3.08	0.01

[a] N = number of paired surveys.

served on a shoreline differed between high and low boat use days, (2) to determine if differences existed in response to boat disturbance by different age classes of eagles, (3) to determine if distance perched from the shoreline or distance flushed by a boat differed between high and low boat use days, and (4) to determine if differences in activity, habitat use, perch use, or interactions occurred between high and low boat use days.

Study Area and Methods

Data on effects of boating activity on eagles were obtained at Lochloosa, Newnans, and Wauberg lakes in Alachua County, Florida. Lochloosa and Newnans lakes are large fishing lakes in the region and the majority of boating activity involved fishing from stationary boats. Wauberg is a small lake with restricted access for gasoline-powered boats but heavily used for recreational activities, primarily canoeing, sailboating, and occasionally fishing from small boats equipped with electric motors (Wood 1992). Newnan's Lake is a hyper-eutrophic lake of 2433 ha (Shannon and Brezonik 1972) with a mean depth of 1.5 m (maximum = 4.0 m). Lake Lochloosa is a 2235 ha meso-eutrophic lake with a mean depth of 2.9 m. Lake Wauberg is a 101-ha eutrophic lake with a mean depth of 3.8 m (maximum = 5.2 m). The lakes are rimmed primarily with baldcypress (*Taxodium distichum*) and hardwood swamps with adjacent pine (*Pinus* spp.) forests.

Lakes were surveyed every 2 wks on Sundays and Mondays from 28 February–9 May 1988, and on Sundays and Tuesdays from 11 December 1988–4 April 1989, to compare days with high human use (Sundays) to low-use days (weekdays). On Newnans and Lochloosa lakes, we surveyed a route of approximately 7 km from a johnboat by driving slowly (about 3–5 knots) approximately 100 m from the shoreline. Because Wauberg Lake is much smaller, we surveyed the entire shoreline from an anchored boat at the center of the lake. Each sampling day was divided into morning, midday, and late-day and a sampling schedule was devised so that each lake rotated through these periods throughout the season. On a given sampling day, we conducted 6 surveys; 2 successive surveys were conducted on a lake before moving to the next lake. We began the first survey shortly after dawn, and finished the last of 6 surveys near dusk. We began each of the 6 surveys at the same time on the two paired sample days.

Data recorded for each eagle observed included location, age class, activity, habitat, perch type, distance perched from edge, interactions, and with whom the interaction occurred. Age classes were based on plumage characteristics (McCollough 1989) and included adults (all white head and tail), late subadults (some brown in head and tail), early subadults (no white in head or tail), immatures (first year eagles), subadults (birds that could not be classed as early or late), and unknowns. Locations of eagles and boats were plotted on topographic maps. In 1989, the distance from our boat at which a perched eagle flushed was estimated with periodic verification using a Lietz range finder.

I first determined the sample size needed to test the hypothesis that boating activity was reducing eagle use of lakeshores using the prespecified variance method (Gilbert 1987:51–52). Data were analyzed separately for 1988 and 1989 for each lake with a paired difference t-test to avoid problems with temporal changes in eagle and boat abundance.

I used a t-test to examine the effect of boating activity on the distance eagles perched from the edge of the shoreline and on the estimated flush distance. Analysis of variance was used to examine month and age variations in flush distance. I used χ^2 contingency tests (Winkler and Hays 1975: 825–829) to examine the distributions for age of eagles observed, habitat use, perch types, activity, and interactions on weekends versus weekdays.

Results

On Lochloosa Lake, boats were more abundant on weekends than on weekdays in both years (Table 1), while more eagles were observed on weekdays than on weekends. The maximum number of boats generally was greater in 1988, while the highest maximum number of eagles occurred in 1989. Likewise on Newnans Lake, boats were more abundant on weekends than on weekdays in both years (Table 1), although the mean difference was not as large in 1989. The number of eagles observed

Table 2. Mean distance (m) Bald Eagles were perched from the edge of the shoreline (1988 and 1989) and flush distance (1989) on weekdays (WD) and weekends (WE) during shoreline surveys of Lochloosa, Newnans, and Wauberg lakes in northcentral Florida.

VARIABLE	N[a]	$\bar{x}$	SE	RANGE	t	P
Distance to edge						
WD	256	5.6	0.56	0–50	−2.52	0.01
WE	193	8.5	0.99	0–75		
Flush distance						
WD	32	53.9	12.32	5–200	0.05	0.96
WE	27	52.9	12.73	5–200		

[a] N = number of Bald Eagle observations.

Table 3. Number of flushes (N) and mean estimated flush distance (m) by month for Bald Eagles sighted on shoreline surveys of Lochloosa, Newnans and Wauberg lakes in northcentral Florida, 1989. Means with the same letter are not significantly different (Waller-Duncan K-ratio t-test).

MONTH	N	$\bar{x}$	SE	RANGE
December	5	5 B	0.0	5–5
January	13	80 A	21.9	5–200
February	20	99 A	14.2	5–200
March	5	5 B	0.0	5–5
April	13	5 B	0.0	5–5
May	3	5 B	0.0	5–5

was not significantly different on weekdays than on weekends in either year. Maximum counts of boats were lower on Newnans Lake in 1989 compared to 1988, but maximum counts of eagles were higher. Fewer boats may affect a smaller portion of the shoreline available to eagles. On Lake Wauberg, there was no difference in the number of boats or eagles observed on weekends versus weekdays in 1988 (Table 1). In 1989, more boats were observed on weekends, but the number of eagles observed did not differ.

Of 816 eagles observed, the majority (47.9%) were adults. The age distribution of eagles sighted on weekends did not differ from that on weekdays ($\chi^2 = 4.01$, $P = 0.55$). Weekend boating activity, therefore, was related to eagle numbers regardless of age class. Eagles perched farther from the shoreline edge on weekends (Table 2) when boating activity was higher than on weekdays with less boating activity, although the difference was only 3 m.

Of 517 eagle sightings in 1989, eagles flushed in response to our boat in 59 instances. Flush distance did not differ between weekends and weekdays (Table 2), but differed by month (Table 3; F = 10.46, $P = 0.0001$). Eagles were flushed by boats at a greater distance in January and February, when boating activity typically increased with winter tourism. Flush distance did not differ by age class (F = 1.23, $P = 0.32$).

During the shoreline surveys, I identified five types of perches: snags, pines, cypress, hardwoods, and palms. There was no difference in the distribution of eagles using these perch types on weekends (high boat use days) compared to weekdays ($\chi^2 = 5.74$, $P = 0.33$). The majority of the 489 sightings of perched birds occurred in cypress (51.9%) or hardwood (21.1%) trees.

I also distinguished six habitat types used by eagles: cypress, hardwood, pinewoods, marsh, lake, and developed (Wood 1992). Eagles used these habitats in the same proportion on weekends as on weekdays ($\chi^2 = 3.85$, $P = 0.57$). The most frequently used habitat was cypress (46%). Pinewoods (22%) and lake (21%) also were commonly used habitats but only 21 (3%) eagles occurred in developed habitats.

Six categories of interactions were observed and involved 332 sightings of eagles: chasing or being chased (31%), perched together (44%), flying together (20%), and stooping on, hitting, and talon locking (5%). Because of small sample sizes, stooping on, hitting, and talon locking were combined into one category for analysis purposes. Boating activity did not change the distribution of eagles engaged in the various interactions ($\chi^2 = 3.56$, $P = 0.31$).

DISCUSSION

Boat and eagle numbers were negatively related on Lochloosa Lake with boat use highest on weekends and eagle use highest on weekdays. On Newnans Lake, the mean difference in the number of boats was not as large as that observed for Lochloosa Lake, particularly in 1989. The small difference in boating activity between weekends and weekdays, although significantly different, may not have been a true measure of boating effects on eagles because of the overall low number of boats present. On Newnans Lake, the maximum number of boats counted on the 7-km segment of shoreline (1988 = 36, 1989 = 16) was much less than on

Lochloosa Lake (1988 = 50, 1989 = 24). There may be a threshold number of boats required on a lake before eagles avoid an area. In contrast, McGarigal et al. (1991) reported a reduction in the use of highly used foraging areas in response to a single stationary boat.

No relationship was detected between boat and eagle numbers on Lake Wauberg. Because this lake is used primarily for recreational activities other than fishing (sailing and canoeing), boat disturbance is concentrated during early afternoon with little disturbance in the early morning and late evening. This allowed eagles to forage undisturbed on the lake for several hours when foraging by eagles generally reaches a peak (Mersmann 1989). Further, Lake Wauberg has restricted access for boats powered with gasoline engines, so disturbance created by a fishing boat is less than that on other lakes. The type of boat and timing of boating activity both can affect response by eagles (Grubb and King 1991, Grubb et al. 1992, Stalmaster and Kaiser 1998).

Human disturbance could at times alter behavior patterns or differentially affect individual age classes (Stalmaster and Newman 1978). In my study, boating activity did not affect eagle activity, perch use, habitat use, interactions, or the age distribution of eagles observed. Thus, eagles likely were not displaced from preferred perching or foraging areas and were not differentially affected by age class.

In my study, flush distance did not differ between weekends and weekdays. In contrast, Stalmaster and Kaiser (1998) found shorter flush distances on weekends. I generally found that when eagles responded to boat disturbance the primary response was to avoid the lakes. Similarly, Steenhof (1976) and McGarigal et al. (1991) found that it was more common for eagles to entirely avoid areas where boats were present. I found no difference in flush distance between age classes. Knight and Knight (1984) and Buehler et al. (1991) reported no age-specific differences in flush distance, whereas Stalmaster and Kaiser (1998) detected longer flush distances by subadults. Stalmaster and Newman (1978) reported that adults were more sensitive to disturbance than younger eagles and preferred areas with lower human activity.

Mean flush distance of 53 m was less than that reported in other studies (Knight and Knight 1984: 152 m; Buehler et al. 1991: 175 m in summer and 265 m in winter; McGarigal et al. 1991: 197 m; Stalmaster and Kaiser 1998: 111–293 m). Buehler et al. (1991) suggested that the difference in winter and summer flush distances observed on the Chesapeake Bay might be a difference in response by the northern migrant eagles inhabiting the Chesapeake in the winter, compared to the southern migrants and Chesapeake eagles present in summer. Because flush distance in my study was very low, particularly after high boat disturbance in January and February, it is possible that eagles habituated to boat disturbance in Florida which contributed to the low summer flush distance observed on the Chesapeake Bay. Knight and Knight (1984) reported a decreased tendency for eagles to flush in response to a canoe, but could not conclusively attribute the response to habituation. Stalmaster and Kaiser (1998) found decreased flush responses over the winter season, but no change in flush distances suggesting some habituation to disturbance.

In summary, boating activity reduced the number of eagles using the shoreline on only one of the three lakes studied, did not influence flush distance, and increased the distance perched from the shoreline by only 3 m. Thus, at this time, there was no evidence that recreational boating activity negatively affected eagle use of these lakes. The minimal flush distances and the lack of measurable effects on eagle behavior and activity patterns suggested that many of these birds may have become habituated to boating disturbance, although they still show some avoidance behavior.

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